Chapter 10

ANALYTICAL TOOLS AND MODEL ASSUMPTIONS

ANALYTICAL TOOLS

Computer models were used extensively to assist in development of this plan. The models represent the performance of a real system through a series of equations which describe the physical processes that occur in that system; they represent a simplified version of the real world that may be used to predict the behavior of the modeled system under various conditions. Models were used to simulate the potential impact of 1990 estimated water demands and projected water demands on the environment and ground water sources in the UEC Planning Area, during a 1-in-10 year drought condition and average rainfall conditions. Information from local comprehensive plans, utilities, University of Florida Institute of Food and Agricultural Sciences (IFAS), and the District's permitting data base was used to support this analysis. Where specific information was not available, conservative professional judgement was used.

Analytical tools used in this analysis included surface water budgets, numerical ground water models, and vulnerability mapping. Surface water budgets were used to approximate surface water availability in each of the major surface water basins in order to quantify the demands that could not be satisfied by surface water. The ground water models were used to identify potential impacts of water use on the environment and ground water resources. Vulnerability mapping was used to identify areas where there is the potential for future saltwater intrusion in the SAS. A process diagram of the analytical tools used in the UEC Water Supply Plan is located in Figure 22. Additional information on the analysis associated with this plan can be found in Appendix J.

Surface Water Budgets

Surface water budgets were used to assess surface water availability for water supply in each of the major surface water basins in the UEC region (C-23, C-24, C-25, North Fork St. Lucie River, Tidal St. Lucie), except the C-44 Basin. The surface water budgets indicate whether there is a surplus or deficit (a deficit of surface water would indicate there is insufficient surface water to meet demands) of surface water in each of the major canal basins for the rainfall event chosen. For a given surface water basin, the budget considers the inflows and outflows that affect surface water storage. If inflows exceed outflows, then surface water is sufficient to meet the surface water demand. If outflows exceed inflows, then there is not sufficient surface water to meet

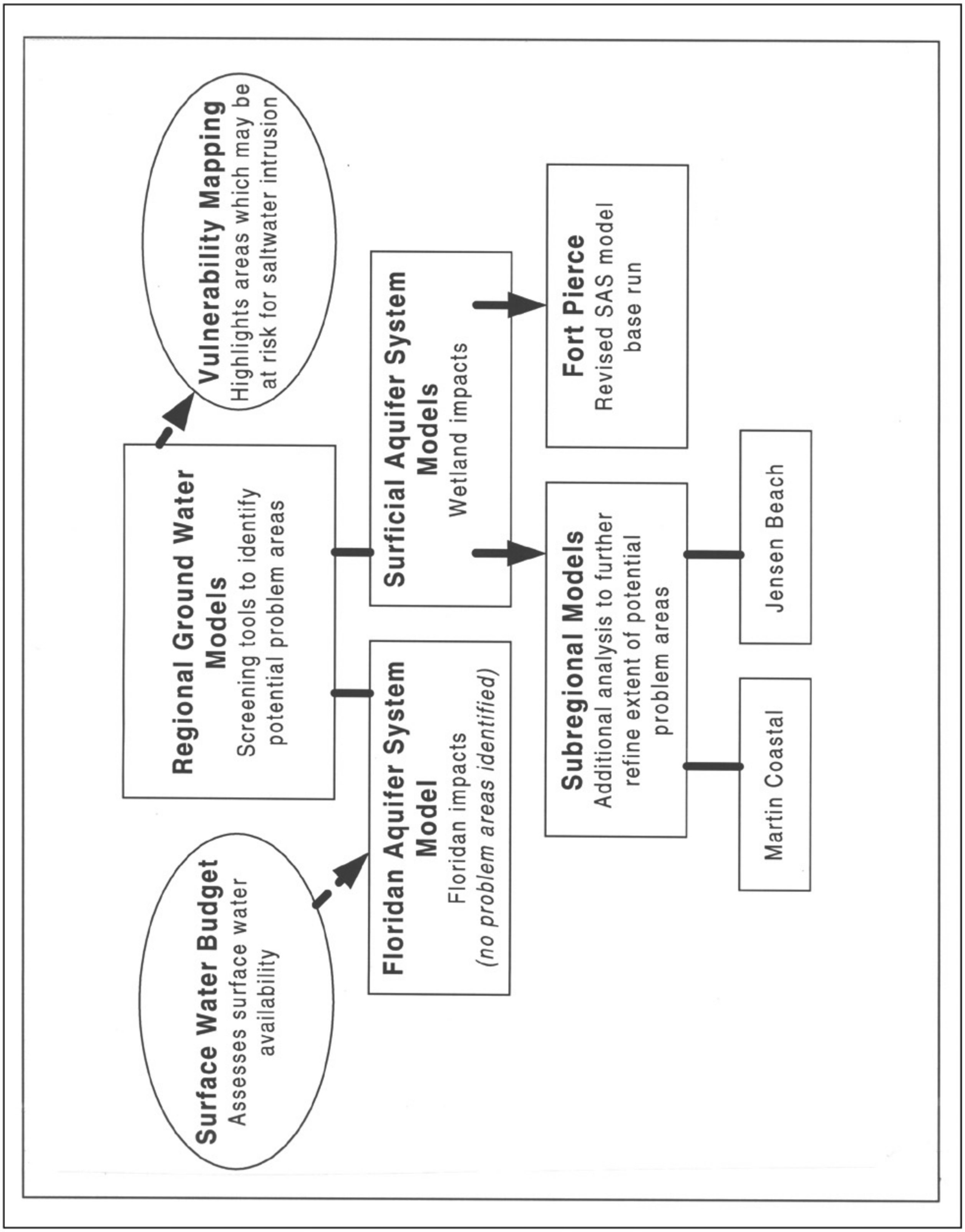

Figure 22. UEC Water Supply Plan Process Diagram and Analytical Tools.

the surface water demand. Unmet surface water needs were distributed to available ground water sources, primarily the Floridan aquifer.

The surface water budgets did not include minimum flows to the St. Lucie Estuary and Indian River Lagoon in that minimum flows have not been determined for these estuarine systems and the tools are not available to analyze the surface water implications. A discussion of minimum flows and levels is provided in Chapter 5. In addition, there are numerous combinations of potential solutions to meet the minimum flow, which are being evaluated in the Indian River Lagoon Restoration Feasibility Study. The results of these efforts will be incorporated into the five-year update of this Plan.

Ground Water Models

Ground water models used in the development of the UEC Water Supply Plan included regional and subregional models. Regional ground water models were used as screening tools to identify areas where water use, based on historical water sources and existing and proposed withdrawal facilities, is potentially impacting the environment or aquifer, during a 1-in-10 year drought condition. In locations where there were concentrated areas of potential impacts, more detailed analyses were conducted.

Based on the regional modeling results, three surficial aquifer system (SAS) areas in the UEC Planning Area were identified for additional analysis: (1) the Jensen Beach Area; (2) the Martin Coastal Area; and (3) the Fort Pierce Area. For the Jensen Beach and Martin Coastal areas, finer resolution subregional "zoom" ground water models were used to conduct the additional analysis. The Fort Pierce Area was examined in more detail using the regional SAS model with refined inputs. Figure 23 indicates the areas encompassed by the regional ground water models and the areas that required additional analysis.

Both the regional and subregional ground water models use the U.S. Geological Survey (USGS) modular three-dimensional finite difference ground water flow model, commonly known as MODFLOW (McDonald and Harbaugh, 1988). The finite difference method depends upon the discretization of the region of flow into a finite number of cells within which hydrogeologic properties are assumed to be uniform. MODFLOW was selected because it allows detailed examination of ground water flow, is available in the public domain, is compatible with most computer systems, and it contains many features, which make it easy to use and modify.

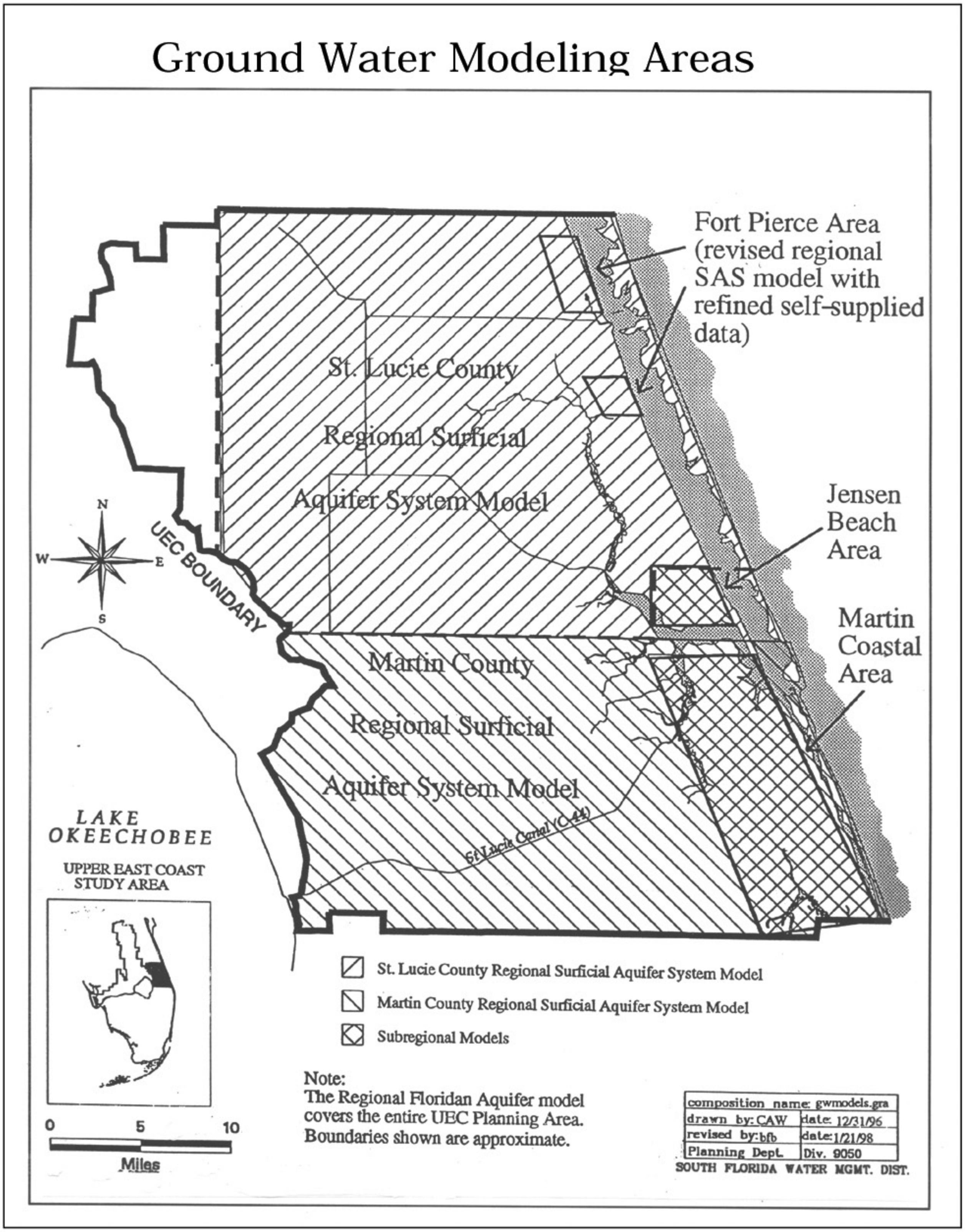

Figure 23. Regional Ground Water Modeling and Subregional Areas.

Each of the ground water models that was used in this plan has been calibrated, tested and reviewed; descriptions and results are presented in SFWMD Technical Publications except for the Martin Coastal Subregional ground water model. The reader who wishes to obtain detailed information regarding model development is referred to Adams (1992) for a description of the Martin County model, Butler and Padgett (1994) for the St. Lucie County model, Lukasiewicz (1992) for the Upper East Coast FAS model and Hopkins (1991) for the Jensen Beach Peninsula Model.

In addition to the identified peer-review of the regional ground water model and Jensen Beach subregional ground water model during their development, the Martin Coastal model and the post-calibration modeling activities for all the ground water models were peer-reviewed for their reasonableness and appropriateness. The reviewers concluded the Martin Coastal model was acceptable, the post-calibration modeling activities were reasonable, and that the overall ground water modeling effort was appropriate for development of this water supply plan.

The area encompassed by the model is divided into cells by a model grid (defined by a system of rows and columns). The ground water models generate two principal types of output, computed head (water levels) which result from the conditions simulated, and water budgets for each active cell. The water budget shows the inflows and outflows for each of the cells.

There are numerous hydrologic properties that the model can represent:

- The aquifer properties of hydraulic conductivity or transmissivity, storage capacity, and vertical conductance
- Initial water level conditions
- Recharge
- Evapotranspiration (ET)
- Ground water/surface water interactions. Rivers and canals can both drain and recharge the aquifer, depending on the relationship of river and aquifer heads; drains do not recharge
- Wells, as either discharge or recharge

Regional Ground Water Models

Three regional ground water models were used to simulate the potential impacts of water use in the UEC region: (1) the Martin County Surficial Aquifer System Model; (2) the St. Lucie County Surficial Aquifer System Model; and, (3) the Floridan Aquifer System Model which encompasses the entire UEC Planning Area. The Surficial Aquifer System models are comprised of cells that are 2,000 feet by 2,000 feet, while the Floridan Aquifer System model is comprised of cells that are one mile by one mile.

These regional models were developed by District staff and documented in peer-reviewed technical publications prior to their use in the UEC Water Supply Plan effort. The regional models were updated to reflect 1990 and future water use demands.

Subregional Ground Water Models

Aside from the regional models, two finer resolution subregional SAS models were used for the Jensen Beach Area and Martin Coastal Area to determine if the potential impacts were an artifact of the scale of the regional models or water use. The ability of the ground water models to reflect the actual ground location of a withdrawal is a function of the cell size or scale used in the model. All withdrawals (wells) that fall within the boundaries of a cell are viewed as coming from the center of that cell, regardless of their specific location. Because of this, as cell sizes are decreased, withdrawals are placed closer to their actual position. The same holds true for the position of wetlands. Consequently, by using the finer scale models, the models more closely represent actual conditions.

The Jensen Beach Area subregional SAS model (Jensen Beach model) was an existing model developed by District staff and documented in a peer-reviewed technical publication that was updated for this planning effort. The Jensen Beach model encompasses the Jensen Beach peninsula in Martin County and is comprised of cells that are 240 by 240 feet. Approximately 69 Jensen Beach model cells fit into one regional model cell.

The Martin Coastal Area subregional SAS model (Martin Coastal model) was developed during the planning process and encompasses the area from the St. Lucie River south to the Loxahatchee River and from the Atlantic Ocean west to the turnpike and is comprised of cells that are 500 by 500 feet. Approximately 16 Martin Coastal model cells fit into one regional model cell. Documentation on the Martin Coastal Subregional Model is provided in Appendix J.

Vulnerability Mapping

Vulnerability mapping is a technique used to identify potential problem areas, especially in water resource investigations, by weighting key factors that can cause the problem. It was used in the UEC Water Supply Plan to evaluate the potential for saltwater intrusion. The factors and weights used in this evaluation were: water levels or heads (50%), proximity or distance to saltwater (25%), and potential (25%). The potential factor is calculated from flow through a cell, magnitude of the flow, and "historic" or "previous" chloride recordings greater than 100 mg/L. Several of these factors were outputs from the regional SAS models. Vulnerability mapping for this application highlights areas that have the highest potential for saltwater intrusion relative to the rest of the region. It does not determine areas that have or will have saltwater intrusion.

Vulnerability mapping is intended to provide a comprehensive view of the potential for saltwater intrusion within the region. By identifying those areas most vulnerable to saltwater intrusion, the plan provides users and regulators the foundation from which to take a strong proactive approach to the management of saltwater intrusion.

MODEL ASSUMPTIONS

The model is first calibrated by matching computed responses to observed conditions in the natural system. During this process, certain data and assumptions are applied to the range of conditions that the model can represent. Once calibrated, certain conditions can be varied to represent alternate circumstances, while others remain fixed. Conditions of water levels, recharge, evapotranspiration, wells, and surface water can be altered to determine response to stress. Those that remain fixed are the area discretization and the aquifer properties. Following is a description of the conditions and assumptions used in each of the models for predictive planning purposes. Additional discussion and information of the post-calibration modeling activities is provided in Appendix J.

Water Supply Needs

The water supply needs or water demands for human uses (public water supply and residential self supplied) and irrigation uses (agriculture, turf grass, etc.) needs to be reflected in the analysis. The methodology and projections for these uses are explained in Appendix G in addition to the information provided below.

It was assumed water use characteristics and management conditions would remain the same as 1990. It was assumed that future water users would obtain water from the same sources as existing users. It was further assumed that existing water users would utilize the same sources for both their current and future demands unless information was made available indicating a change. The existing and projected use of reclaimed water (where information was available) was incorporated into the simulations, as well as reductions in public water supply water use resulting from implementation of mandatory conservation measures.

Public Water Supply and Residential Self Supplied Demands

Public water supply and domestic self-supplied demands were based on historic per capita water use and monthly distribution patterns. Actual pumpage information was used in the 1990 model simulations, while projected demands were based on population projections from local government comprehensive plans. Public water supply demand was taken from existing and/or proposed facilities. Some of these facilities may not have been intended to supply that level of demand. Simulated pumpages, facilities, and sources for each utility are provided in Appendix J.

For the regional model runs, self-supplied demand, which is not usually incorporated in the cumulative analysis associated with consumptive use permitting, was uniformly distributed over utility service areas and planning areas. More refined data inputs were developed for the subregional analysis. Specifically, rather than distributing domestic self-supplied demand evenly over an entire planning or utility service area, more precise locations for domestic self-supplied and small water treatment “package” plant withdrawals were determined by looking at aerial photographs and meeting with utility representatives. Maps indicating the location of residential self-supplied areas are located in Appendix J.

Recharge from septic tanks was not incorporated into the analysis, but local public health units estimate these systems are treating up to 8 mgd in the UEC Planning Area. Recharge from septic tanks could potentially offset potential impacts from residential self-supplied users, since many wells coexist with septic tanks.

Irrigation Demands

All irrigation demands were calculated using the modified Blaney-Criddle method for each rainfall condition. A detailed discussion of this method can be found in the District’s Management of Water Use Permitting Information Manual, Volume III (1994). Blaney-Criddle is currently used in estimating supplemental crop requirements in the District’s consumptive use permitting (CUP) program.

The Blaney-Criddle model calculates monthly ET based on average air temperature, hours of daylight, and growth coefficients of a crop. Effective rainfall is then determined, based on ET rate, rainfall amount, and soil water retention capability. Finally, the supplemental irrigation requirement is calculated, as the difference between ET and effective rainfall. The 1990 demand level represents the estimated agricultural water demand for the use type and acreage that was permitted by the District through the end of 1990. The associated demand was then calculated based on the simulated rainfall event. The future demand level is based on projected agricultural acreage. The location of withdrawals was based primarily on the District's CUP database.

Rainfall Recharge

Two rainfall conditions were simulated to identify the difference between likely chronic problems, occurring under average rainfall conditions, versus problems expected only during droughts. A 12-month dry rainfall event that occurs, statistically, no more frequently than once every ten years was simulated for each county. This rainfall event is referred to as a 1-in-10 year drought condition or a 1-in-10 level of certainty. Rainfall is discussed in greater detail in Appendix C.

All recharge to the models was assumed to be derived either from rainfall or from lateral recharge from outside the model boundaries. Not all rainfall becomes recharge; some is used by vegetation and some evaporates from the ground surface before it infiltrates. In the Surficial Aquifer models, generally between 60 and 85 percent of monthly rainfall ultimately become recharge to the models. There is no rainfall-derived recharge to the FAS model.

Evapotranspiration

Evapotranspiration (ET) is assumed to be a function of potential ET. This maximum rate occurs when water levels are at or above an ET surface assumed to be equivalent to or slightly below land surface. The rate diminishes as water levels approach the extinction depth, which is a function of land use, predominant vegetation type, or both.